

Submitted to:  
US EPA Region 8  
Denver, CO

Submitted by:  
Atlantic Richfield Company  
Butte, MT  
August 25, 2011

# Field Sampling Plan for Solids Repository, Permanent Drying Facility and Pond Flood Dike and Embankment Improvements

Rico-Argentine Mine Site – Rico Tunnels  
Operable Unit OU01  
Rico, Colorado

# Atlantic Richfield Company

Atlantic Richfield Company

317 Anaconda Road  
Buda, MT 59701  
Direct (406) 782-9984  
Fax (406) 782-9980

August 25, 2011

Mr. Steven Way  
On-Scene Coordinator  
Emergency Response Program (8EPR-SA)  
US EPA Region 8  
1595 Wynkoop Street  
Denver, CO 80202-1129

**Subject: Field Sampling Plan**  
Rico-Argentine Mine Site – Rico Tunnels  
Operable Unit OU01 Rico, Colorado

Dear Mr. Way,

Please find enclosed three (3) copies of the *Field Sampling Plan* dated August 25, 2011. Atlantic Richfield is submitting the *Plan* responsive to Tasks B, C, and F of the Removal Action Work Plan, Rico-Argentine Mine Site – Rico Tunnels, Operable Unit OU01 Rico, Colorado dated March 9, 2011.

If you have any questions, please feel free to contact me at 406-782-9964.

Sincerely,



Anthony R. Brown, P.E.  
Project Manager  
Atlantic Richfield Company

Enclosures

cc: R. Halsey, AR  
C. Stilwell, AR  
S. Dischler, AR  
T. Moore, AR  
C. Sanchez, AECI  
T. Kreutz, AECOM (w/o encl.)  
D. Yadon, AECOM (w/o encl.)  
J. Decker, AECOM (w/o encl.)



A BP affiliated company

## Table of Contents

1.0	Introduction .....	1
1.1	Purpose .....	1
1.2	Organization .....	2
2.0	Project Organization, Roles, and Responsibilities.....	2
2.1	Regulatory/Permitting Agency.....	2
2.2	Facility Owner .....	2
2.2.1	Project Manager .....	2
2.3	Investigation Field Manager .....	3
2.4	Certifying/Design Engineer .....	3
2.5	Health and Safety Officer .....	3
2.6	Subcontractors.....	4
2.7	Quality Control (QC) Officers .....	4
3.0	Engineering Geologic Mapping.....	4
4.0	Geotechnical Investigation – Drilling, Sampling and CPT Program.....	5
4.1	Background.....	5
4.2	Proposed Exploration Types and Locations .....	5
4.2.1	North Stacked Repository (NSR) .....	5
4.2.2	Alternative North Drying Facility/Repository (ADF/R) .....	6
4.2.3	South Stacked Repository (SSR).....	6
4.2.4	Permanent Drying Facility (PDF).....	6
4.2.5	Monitoring Wells at Existing Pond 12, 13 & 15 Dikes (MW) .....	7
4.2.6	Flood Dike and Embankments Structural Integrity at Existing Ponds 5-18 (ED)....	7
4.2.7	Drilling and Sampling Methods .....	7
5.0	Geotechnical Investigation - Test Pit and Sampling Program .....	8
6.0	Geotechnical Investigation – Flood Dike Slope Protection Assessment.....	9
7.0	Geotechnical Laboratory Testing Program .....	10
7.1	Testing Program .....	10
7.2	Quality Assurance/Quality Control (CQA/CQC) of Laboratory Testing .....	11

## **List of Figures**

Figure 1	FSP Organization Structure
Figure 2A	Geologic Legend
Figure 2B	Existing Exploratory Locations
Figure 3	Geologic Section A-A
Figure 4	Geologic Section B-B
Figure 5	Geologic Section C-C
Figure 6	Geologic Section D-D
Figure 7	Geologic Section E-E
Figure 8A	Geologic Section F-F (sheet 1 of 2)
Figure 8B	Geologic Section F-F (sheet 2 of 2)
Sheet 9	Proposed Exploration

**Field Sampling Plan**  
**for**  
**Solids Repository, Permanent Drying Facility and Pond Flood Dike**  
**and Embankment Improvements**  
**at**  
**Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01**  
**Rico, Colorado**

**August 25, 2011**

## **1.0 Introduction**

AECOM Technical Services, Inc. (AECOM), in cooperation with Anderson Engineering Co. Inc. (AECI) and on behalf of Atlantic Richfield Company (AR), has prepared this Field Sampling Plan (FSP) for investigation activities in the vicinity of the St. Louis Ponds system. The work described in this FSP is required as part of siting and design of the various facilities to be constructed or enhanced as part of the overall water treatment system. These facilities include pond flood dike and embankment improvements, treatment solids drying facility, and the long-term solids repository.

The work includes: 1) completion of soil borings, cone penetration probes, and test pits in the various areas proposed for drying of lime treatment solids, and for disposal of solids in one or more on-site repositories, and to characterize the structural integrity of the existing ponds system flood dike and pond embankments; 2) installation of piezometers in selected soils borings and construction of monitoring wells in selected locations; 3) documentation of existing slope protection on the river-side slope of the existing flood dike; and 4) laboratory testing of selected samples acquired during the field exploration work. The work is to be performed in the area of the St Louis Ponds, north of Rico, Colorado within Dolores County at the Rico Tunnels Operable Unit OU01 of the Rico-Argentine Mine Site.

### **1.1 Purpose**

The purpose of this FSP is to present a scope of work for subsurface geotechnical investigation and laboratory testing of the existing and proposed facilities noted above. These activities are responsive to the requirements under Tasks B, C and F of the Removal Action Work Plan, Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01, Rico, Colorado dated March 9, 2011 (Work Plan). The results of this investigation will be used in the siting, selection and design of alternative and/or supplemental sites for new facilities required as part of a lime precipitation water treatment system to treat mine adit discharge from the St. Louis Tunnel, and evaluation of upgrades, if required, for the existing ponds system flood dike and pond embankments. While identified in the Work Plan, evaluation of Pond 13 as a potential site for the permanent solids drying facility is not included in this FSP due to the anticipated challenges (e.g., stability and settlement) of constructing on top of previously placed treatment solids that are planned to remain in place.

In parallel with the work required to support design and construction of a water treatment system, additional site activities are underway that may affect the selection of the final water treatment technology for the St. Louis Tunnel site. These efforts include the ongoing source control investigation and technology screening evaluation. While AR is prepared to complete the work required in this FSP, it is possible that selection of the appropriate treatment technology could affect dewatering and solids management requirements. This decision will be made through discussion with the EPA following the initial evaluations which are anticipated to be completed later in 2011.

## **1.2 Organization**

Section 1.0 of the FSP presents the purpose and organization of the report. Section 2.0 outlines the project organization, roles and responsibilities. Engineering geologic mapping of the site and adjacent ground is discussed in Section 3.0. The geotechnical investigation plan for soil borings and cone penetration probes is described in Section 4.0. Section 5.0 presents the geotechnical exploration plan for test pits. Documentation of slope protection on the river-side of the treatment pond embankments (referred to herein as the flood dike) is described in Section 6.0. The laboratory testing plan for samples collected during the subsurface investigation program is outlined in Section 7.0.

## **2.0 Project Organization, Roles, and Responsibilities**

The purpose of this section is to define the areas of responsibility and lines of authority for each organization and for the members of the FSP team to facilitate decision-making during completion of the work.

The project management organization is presented on Figure 1, with the responsibilities of team members described in the following sub-sections.

### **2.1 Regulatory/Permitting Agency**

The U.S. Environmental Protection Agency (EPA) is responsible for overseeing AR's performance of work for consistency and compliance with the provisions of the Work Plan. EPA will designate an individual as its On-Scene Coordinator (OSC). The EPA or their oversight contractor will periodically be on site during exploration activities.

### **2.2 Facility Owner**

AR has the responsibility for implementing the work described in the FSP. AR will coordinate overall management and implementation of the St. Louis Ponds area investigation activities.

AR is responsible for complying with the Project Documents and has the authority to select and dismiss subcontractors for completion of the investigation. AR also has the authority to accept or reject plans and reports, recommendations of the Investigation Field Manager, and the materials and workmanship of the various Contractors who may work on the site.

#### **2.2.1 Project Manager**

Mr. Tony Brown has been selected as AR's Project Manager. Mr. Brown will be AR's key contact person for EPA during the work. The Project Manager will also:

- Approve and sign submittals and progress reports. The Project Manager may authorize others to sign submittals and progress reports on his behalf.

- Certify that the investigation has been completed in accordance with the approved FSP. The Project Manager will sign the Completion of Investigation Report in addition to the AECOM Certifying/Design Engineer.

### **2.3 Investigation Field Manager**

Mr. Christopher Sanchez, Certified Safety Professional (CSP) (AECI) will serve as the Investigation Field Manager. The duties of the Investigation Field Manager include:

- Report to the Project Manager for AR and to the Certifying/Design Engineer.
- Identify and coordinate scheduling of drilling, cone penetration probe, and test pit excavation subcontractors.
- Oversee on-site investigation activities, including soil boring and test pit field sampling and logging, oversight of cone penetration probes, and documentation of existing slope protection on the flood dike.
- Chair on-site project meetings related to the investigation work.

### **2.4 Certifying/Design Engineer**

Mr. Doug Yadon, PE (AECOM) will serve as the Certifying/Design Engineer. The Certifying/Design Engineer is responsible for preparation of the final report resulting from the investigation work. In addition, the Certifying/Design Engineer or his designee will be responsible for:

- Selection of the number and location of borings and test pits, the depth of exploration at borings, monitoring wells, and CPT probes, and the potential use of coring in rock if encountered prior to and during the course of exploration.
- Periodic observation of the investigation work to assure that the work is in agreement with the intent of the FSP and the anticipated design requirements.
- Reduction, interpretation and analysis of field and laboratory geotechnical data.
- Preparation of the laboratory testing program based on exploration results, and selection and oversight of the geotechnical laboratory.
- Preparation of a final technical memorandum (TM) (which will serve as the Completion of Investigation Report). The TM will discuss the results of the exploration as related to the required evaluation and design of facilities.
- Participate in key technical discussions with EPA and the various subcontractors.

### **2.5 Health and Safety Officer**

Mr. Christopher Sanchez, CSP (AECI) or his appointed designee will serve as the Health and Safety Officer (HSO). The HSO will ensure that all Health and Safety Plan (HASP) requirements are effectively employed and enforced during investigation activities completed on-site.

## **2.6 Subcontractors**

The Drilling, Excavation and CPT Subcontractors for the FSP will be identified and contracted by AECI with input and concurrence by AECOM and final authorization by AR. The Geotechnical Laboratory for the FSP will be identified and contracted by AECOM with final authorization by AR. Information regarding the task specific Subcontractors will be provided to EPA as those Subcontractors are selected. The Subcontractors will be responsible for supplying materials and labor to complete the investigation in reasonable conformity with the requirements of this FSP. As such, each Subcontractor is responsible for quality control (QC) to ensure that the work meets the requirements of this FSP.

Before performing work at the site, the Subcontractor(s) will ensure that all necessary EPA approvals, authorizations, and coordination for EPA oversight have been secured or arranged.

The subcontractors will immediately notify their respective QC Officer of unanticipated conditions encountered during the investigation or another conditions that the subcontractor believes could affect the ability of the investigation to meet the design objectives. The QC Officer shall in turn notify the Investigation Field Manager for any concurrence or direction to respond to the unanticipated condition(s). The Investigation Field Manager will receive input from the Certifying/Design Engineer in matters that will or could affect the integrity of the analyses or designs to be based on the results of the field exploration program.

## **2.7 Quality Control (QC) Officers**

Each subcontractor will designate a QC Officer. The QC Officer is responsible for:

- Performing observations and tests by verifying that:
  - Regular calibration of investigation equipment is properly conducted and recorded.
  - The investigation equipment, personnel and procedures do not change over time or that any changes do not adversely impact the investigation process.
  - The boring, test pit and CPT sampling and test data are accurately recorded and maintained.
- Identifying deficient work items and recommending corrective actions.
- Ensuring that agreed-upon corrective actions have been conducted and are sufficient to correct the deficiency.

Planned and actual locations for boring, CPT, test pit, monitoring well, and flood dike documentation locations will be surveyed by AECI in an accurate and timely manner.

## **3.0 Engineering Geologic Mapping**

A preliminary geologic map has been compiled based on published geologic maps and limited site reconnaissance (see Figures 2A and 2B). The objective of the mapping planned under this task is to update the preliminary geologic mapping and accompanying cross-sections for the purpose of developing an engineering geologic model of the site. This model will be further updated and refined based on the results of the other field investigations described later in this TM.



Available aerial photography and other remote imagery of the site and adjacent ground will be acquired, compiled and reviewed prior to initiating field engineering geologic mapping. This will include photo-interpretation of geologic conditions as inferred from aerial imagery together with published small-scale geologic mapping. The photo-interpretation will include identifying and mapping any evidence of surficial and bedrock unit contacts, prominent jointing, faults or fault zones, areas of seepage, and slope instability (landslides, rockfalls, debris slides, etc.). Mining related features will also be identified and mapped, including existing and closed adit/tunnel portals and shafts and waste rock piles. Field engineering geologic mapping of the site and adjacent CHC Hill will be performed and compiled on the most recent project topographic base map at a scale not smaller than one (1) inch = 200 feet. Field mapping will involve ground traverses and outcrop observations, existing cut slopes and excavations, and other features of interest within the mapping area.

## **4.0 Geotechnical Investigation – Drilling, Sampling and CPT Program**

### **4.1 Background**

Substantial subsurface exploration and reconnaissance geologic mapping have been performed at the St. Louis Ponds site over at least the past 30 years. Figures 2A and 2B provide a legend and map showing the approximate locations of previous investigations at the site and geologic units visible at the existing ground surface. Figures 3 through 8 are geologic cross-sections based on the prior exploration and geologic mapping. This previous subsurface and reconnaissance mapping information was used, together with conceptual layouts and planning of future facilities, to develop the supplemental subsurface investigation program described in this FSP.

### **4.2 Proposed Exploration Types and Locations**

Figure 9 shows the location of primary features to be characterized and the approximate location of borings, monitoring wells, and CPT probes. The exploration at each primary site or facility is described in Sections 3.2.1 through 3.2.6. Drilling and sampling methods are described in Section 3.2.7. The latest edition of the Engineering Geology Field Manual published by the U.S. Bureau of Reclamation (<http://www.usbr.gov/pmts/geology/geoman.html>) will be used as a general guide for performing the subsurface investigations.

#### **4.2.1 North Stacked Repository (NSR)**

A key objective of the investigation at the NSR site is to characterize the repository subgrade, including acquiring information to support evaluation of the translational stability of the fill/mine waste/demolition debris, landslide, and alluvial materials known or inferred to underlie the site. To accomplish this objective, two (2) rotary drill (RD) or hollow-stem-auger (HSA) borings will be drilled to 60 feet or drilling refusal (whichever is shallower), in the miscellaneous fill/mine waste/demolition debris and underlying alluvial and/or colluvial deposits west of the toe of CHC Hill. In addition, two (2) RD or HSA borings will be drilled through the lower part of CHC Hill through what is anticipated to be landslide debris and/or colluvium. These borings will also be drilled to 80 feet or refusal or 10 feet into underlying Hermosa Formation or intrusive igneous bedrock, whichever is shallower.

The purpose of these borings is to evaluate depth, stratigraphy and Standard Penetration Test (SPT) density of the existing fill, colluvium, landslide deposits, or other overburden soils relative

to foundation support for one of two alternative or supplemental locations for a stacked solids repository.

#### **4.2.2 Alternative North Drying Facility/Repository (ADF/R)**

The primary objective of the investigation in this area is to characterize subgrade foundation settlement and stability of the ADF/R. To accomplish this objective, two (2) RD or HSA borings will be drilled to 30 feet or drilling refusal, whichever is shallower, in the former heap leach pad area. If a remnant HDPE liner is encountered in the borings, additional test pits or other investigation will be considered and discussed with EPA.

The purpose of these borings is to evaluate depth, stratigraphy and SPT density of the existing fill and alluvial soils, relative to foundation support for an alternative or supplemental location for the permanent solids drying facility or repository.

#### **4.2.3 South Stacked Repository (SSR)**

The primary objective of the investigation of the SSR is to characterize the subgrade foundation settlement and stability in the Pond 16/17 area, especially in areas underlain by calcine tailings relative to foundation support for one of two alternative or supplemental locations for a permanent stacked solids repository.

To accomplish this objective, three (3) RD or HSA borings will be drilled to 60 feet or refusal (whichever is shallower) through the existing calcine tailings and alluvium at the eastern edge of the former Pond 16/17 area. Also two (2) RD or HSA borings will be drilled into the lower part of CHC Hill (highest part of the proposed SSR) to drilling refusal or 10 feet into Hermosa Formation or igneous intrusive bedrock, whichever is shallower.

The purpose of these borings is to evaluate depth, stratigraphy and SPT density of the fill (especially calcine tailings), alluvium and colluvium, and characteristics of bedrock (if encountered).

#### **4.2.4 Permanent Drying Facility (PDF)**

The objective of the investigation at the PDF is to evaluate the existing embankment fill, calcine tailings, and alluvial soils relative to foundation support for the currently preferred site for the permanent solids drying facility.

To accomplish this objective, two (2) RD or HSA borings will be drilled to 30 feet or drilling refusal, whichever is shallower, through the existing calcine tailings and alluvium in the main part of the former Pond 16/17 area. A minimum of four (4) Shelby tube samples of the calcine tailings will be collected, with a minimum 18 inches of recovery each from each boring. One (1) RD or HSA boring will be drilled to 30 feet or drilling refusal, whichever is shallower, in the dike separating the former Pond 17 from Pond 18.

Also six (6) cone penetration test (CPT) probes will be completed through the calcine tailings and into the underlying alluvium to 30 feet or refusal, whichever is shallower. Tip and sleeve resistance and pore pressure will be recorded and stratigraphy will be inferred (correlated approximately with nearby soil borings).

The purpose of these borings and probes is to evaluate depth, stratigraphy and SPT/CPT density of the existing embankment fill, calcine tailings, and alluvial soils.

#### **4.2.5 Monitoring Wells at Existing Pond 12, 13 & 15 Dikes (MW)**

The primary objective of this investigation is to evaluate groundwater and seepage conditions within the flood dike and pond embankments and their foundations in the area of the upper ponds where existing data is sparse. This investigation will also provide additional information on the geotechnical conditions of these existing embankments and their foundations.

To accomplish these objectives, six (6) pairs of shallow groundwater monitoring wells will be installed. One well will be screened in saturated dike material (typical depth of 15 feet) and the other well will be screened in alluvium below the respective adjacent pond bottom elevation (typical depth 25 feet). Paired wells are proposed to be 10 feet or less apart. The deeper well will also be logged and sampled while the RD or HSA boring is being advanced.

The purpose of these monitoring wells is to provide additional information on groundwater levels to support evaluation of removal of existing treatment solids in the upper ponds. These results will be used to evaluate the need for pond flood dike and embankment and/or foundation upgrades and stabilization. The information from drilling and sampling the monitoring wells will also support evaluation of the depth, stratigraphy and SPT density of the existing flood dike and embankment fill and alluvial foundation soils (from the RD or HSA samples), and the relative piezometric (groundwater) levels in the dike/embankment fill and underlying alluvium.

#### **4.2.6 Flood Dike and Embankments Structural Integrity at Existing Ponds 5-18 (ED)**

The objective of the investigation of the existing flood dike and pond embankments is to evaluate the need for pond flood dike and embankment and/or foundation upgrades and stabilization to address foundation and slope stability and seepage conditions, and piping potential.

To accomplish this objective, six (6) RD or HSA borings (one boring each at Ponds 6, 7, 8, 9, 10/11, and 14/15) will be drilled to 30 feet or refusal, whichever is shallower. Three (3) of these borings will be located in the flood dike and three (3) will be located in pond embankments.

The purpose of these borings is to evaluate depth, stratigraphy and SPT density of the existing flood dike and pond embankments fill and alluvial foundation soils.

#### **4.2.7 Drilling and Sampling Methods**

Typical sampling criteria for rotary drill (RD) or hollow stem auger (HSA) borings are described as follows. Beginning at the surface, use a 2.5-foot sampling interval through fill zones (e.g., waste rock, tailings, random fill); use a 5-foot sampling interval through underlying alluvial, colluvial and/or landslide materials unless the SPT penetration resistance is  $N < 20$  blows per foot (bpf), in which case revert to a 2.5-foot sampling interval. Use a standard 2-inch-OD split-spoon sampler and SPT method per ASTM D 1586. AECI and AECOM engineering geologists or geotechnical engineers will keep a detailed log of each of the borings. The logs will include, but are not limited to, information on: drilling methods and equipment used; difficult or problematic drilling conditions (e.g., loss of drill fluid for RD drilling, refusal for RD or HSA drilling); depth of noticeable changes in material type; description of materials encountered (gradation, plasticity, density or consistency, color, moisture condition for soils); bedding, nature of contacts between units (sharp, gradational, etc.); structure or features of interest (roots, organics, fissures, voids, precipitates/salts, staining, etc.); depth interval, type and recovery of samples; SPT blow counts; and depth to groundwater if encountered. The inferred presence of

coarse gravel, cobbles or boulders encountered in the borings will be noted on the logs to support proper interpretation of SPT blow counts.

Disturbed samples from SPTs will be placed in labeled zip-lock bags to preserve gradation and moisture content for laboratory testing. Thin-wall tube (i.e., Shelby tube) samples of cohesive soils or calcine tailings will be labeled, capped and taped in the field. If the tube samples will be held for more than 24 hours prior to testing or storage in a controlled humidity room, the caps will be sealed in microcrystalline wax.

If perched water is encountered above alluvial groundwater in RD or HSA borings (other than the monitoring wells described in Section 3.2.5 above) a decision will be made in the field as to installing a piezometer to permit monitoring that groundwater level over time. This decision will be based on the location of the boring, the depth to groundwater relative to the facility site being explored, and the presence of existing piezometers or monitoring wells that adequately monitor that higher groundwater condition.

Where bedrock is encountered, borings will be extended a minimum of five (5) feet into rock to confirm presence, lithology, jointing/fracturing, and weathering of the rock, utilizing rotary drilling and/or coring as determined by AECOM in consultation with AECl. The decision as to whether to core will depend on the location of the boring and the depth to rock relative to the facility site being considered in a particular location. If coring is performed, the crew will note gain or loss of coring fluid, if encountered. Recovered core will be logged and photographed. Rock cores will be marked in the field for top versus bottom of the core run, and stored in purpose-made cardboard or wooden core boxes.

Boreholes that are not to be completed as monitoring wells or otherwise completed with a piezometer will be abandoned upon completion using a fluid cement/bentonite grout in conformance with any applicable state regulations.

## **5.0 Geotechnical Investigation - Test Pit and Sampling Program**

It is anticipated that test pits will be required to supplement the information collected from the drilling and CPT program described above. The primary objectives of the test pits are to: 1) observe and sample the full range of gradation, structure and consistency (density) of selected fill and native soils, especially those characterized by coarse gravel, cobbles and/or boulders; and 2) perform in situ density tests of suitable gradation soils.

To accomplish this objective, up to 24 test pits will be excavated using a track-mounted excavator with at least a 20- to 25-foot reach. Proposed locations for test pits are not shown on the attached exploration map (Figure 9) as the locations will be selected by AECOM with input from AECl based on the soil boring and CPT results, safety, and accessibility. Target areas for test pits include dike embankments, potential on-site borrow areas, buried foundations in the proposed North Stacked Repository footprint, and discrete fill materials (e.g., calcine tailings in the former Pond 16/17 area, or waste rock). Special caution will be implemented if excavating test pits in existing embankment fill. Bulk or trimmed samples will be collected for laboratory testing including tests to determine index properties (moisture content, gradation and Atterberg limits), laboratory moisture/density relationship, shear strength, and possibly hydraulic conductivity. In situ density and water content tests (within OSHA-compliant excavations) will

also be performed in representative test pits using a nuclear density gage (assume 10 test locations).

The engineering geologist or geotechnical engineer will maintain a log of the test pit conditions, including approximate plan dimensions, total depth, depths of strata change, detailed description of materials encountered (including color, approximate gradation, plasticity, etc.), and indication (e.g., mottling) of depth to groundwater. Photographs will be taken to document sidewall stability, groundwater seepage/accumulation, and material variations/stratigraphy.

At completion, each test pit will be backfilled with the material excavated from the pit or other suitable backfill as determined by AECOM or AECI using bucket and track tamping for compaction.

## **6.0 Geotechnical Investigation – Flood Dike Slope Protection Assessment**

The overall purpose of the investigation program in the flood dike river-side slope area is to document existing conditions of slope protection (riprap and/or vegetation), filter zone (if present), and flood dike subgrade along the length of the dike. The purpose of the test pits and samples is to assess: 1) the gradation and thickness of riprap on the slope; 2) the presence and gradation (if present) of a filter layer between the riprap and dike material; and 3) the gradation, plasticity, and apparent density of the dike fill material. This information will be used to assess the overall stability of the existing flood dike between the Dolores River and the ponds.

Observations and documentation will be made of the existing slope protection on the river-side slope of the flood dike from Pond 5 to the northern end of the dike. Documentation will include: 1) placing a nine (9)-foot square highly visible template with a three (3)-foot grid of cross pieces (all constructed of painted PVC pipe or wood lath) on the slope at adjacent locations from one end of the dike to the other (and covering the slope from the water line to the crest of the dike); 2) noting the size range of riprap within the template area at each placement, significant variations of riprap size or grading among the grid spaces, and the nature of the subgrade visible beneath and between riprap rocks; 3) describing any significant vegetation, erosion, sloughing/slumping, seepage, evidence of high water, or other features of interest present; and 4) photographing each template placement from the opposite (west) bank of the river with a digital camera with appropriate telephoto lens so that the template approximately fills the field of view of the photograph.

In at least one (1) of the three (3)-foot grid areas at a minimum of 12 representative template locations along the flood dike, determine the approximate gradation of the riprap by measuring and counting rocks larger than approximately 3-inch maximum dimension; also estimate the approximate percentage of void space within the grid if riprap does not completely fill the grid space. Each placement of the template will be given a distinct identifying number to correlate with field notes and photographs. The start and end of, and at least six (6) additional stations in between, the reach of dike documented will be located by survey and correlated to the template identification number at those stations.

Up to 12 test pits will be excavated using a conventional or mini track-mounted excavator or hand excavation (pick and shovel) in the river-side slope of the flood dike from Pond 5 on the south to the northern end of the dike. Use hand excavation where access by even mini track-hoe is not safe or practical. Perform in situ density and water content tests of the subgrade on

the floor of test pits with OSHA-compliant slopes using a nuclear density gage (assume 12 test locations). Collect grab samples of filter material (if present) and dike subgrade soils at each of the test pit locations for testing in the geotechnical laboratory.

## 7.0 Geotechnical Laboratory Testing Program

### 7.1 Testing Program

The following laboratory testing program is planned, with variations to be determined based on number, length and type of samples recovered:

**Moisture Content:** all recovered samples except clean gravels (GP, GW); used for soil classification.

**Atterberg Limits:** representative clayey silt or clay samples (up to 24); used for soil classification.

**Hand Penetrometer or Torvane:** all tube samples of cohesive soils (clays or clayey silts); used for soil classification and to estimate unconfined compressive strength.

**Unconfined Compression/Dry Unit Weight:** representative cohesive samples (up to 15); used to estimate unconfined compressive strength, undrained shear strength, and unit weight for slope stability and foundation/subgrade analyses.

**Grain Size Analysis:** representative coarse-grained (i.e., predominantly sand and gravel) samples, including miscellaneous fill/mine waste/demolition debris, sidehill colluvium and landslide debris, calcine tailings, and borrow sources (up to 36); with determination of percent passing USCS No. 200 sieve (P200) as appropriate. The results will be used for evaluation of foundation/subgrade stability, seepage analyses through the flood dike, embankment and pond bottoms, and evaluation of borrow sources to provide structural embankment fill and possibly filter and/or drain material.

**Direct Shear.** representative re-compacted sidehill colluvium, dike fill and calcine tailings samples (up to 6). Density of re-compacted samples is to be based on field nuclear density and/or SPT results. The results are to be used for foundation bearing capacity and slope stability analyses.

**Triaxial Shear.** representative colluvium, landslide debris (not failure plane material), dike fill and calcine tailings samples (up to 6). The results are to be used for foundation bearing capacity and slope stability analyses. In addition, a small-diameter (i.e., Harvard miniature mold size) triaxial strength test of solids generated from lime addition to St. Louis adit discharge water in a 2008 experimental study will be performed if sufficient consolidated (dried) solids can be produced from the available slurry samples.

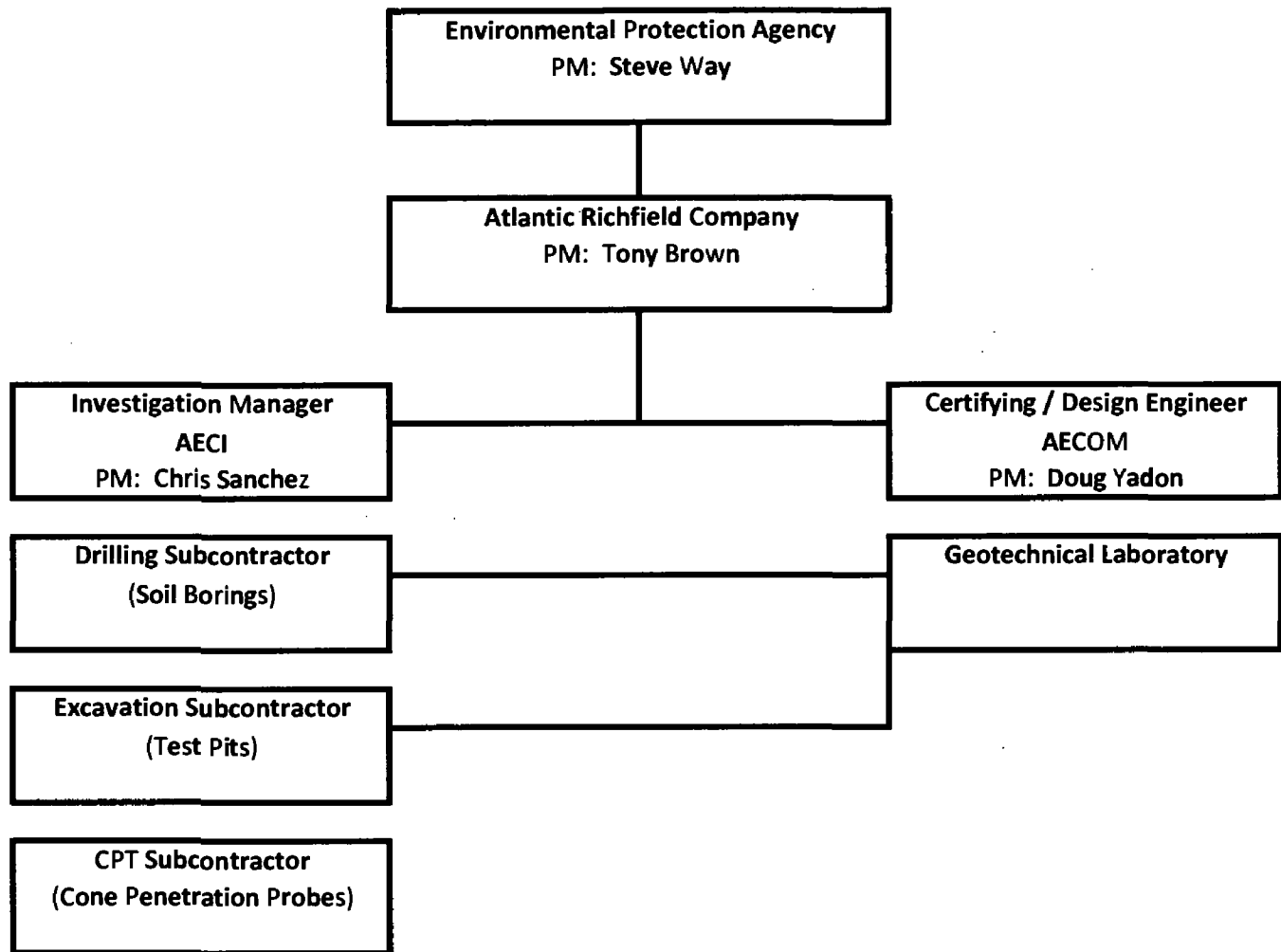
**Moisture/Density (Proctor) Testing:** representative on-site colluvium, landslide debris, fill, waste rock, and possibly selected off-site borrow sources (up to 6). These test results are to be used to establish density and moisture content criteria for engineered fill placement.

**Rock Core Testing:** to be determined if rock core is recovered during the field exploration program; may include unconfined compression, direct shear, and/or tensile splitting testing depending on the characteristics of the core recovered.

## **7.2 Quality Assurance/Quality Control (CQA/CQC) of Laboratory Testing**

AECOM will approve the selected geotechnical laboratory prior to employing the laboratory and prior to commencement of laboratory testing activities. The role of the testing laboratory is to provide laboratory testing of soil (and possibly rock core) samples recovered from the borings and test pits completed as part of this FSP. Laboratory tests will be completed per associated ASTM Standards or other industry recognized standards as agreed to by AECOM.

**Figure 1 - Field Sampling Plan Organization**





## WELLS / BORINGS

- ⊗ DH-1 (ANDERSON ENGINEERING/SEH, 2008)
- ⊕ EW-1, EB-1 (SEH, 2004)
- GW1 (CDPHE, 2003)
- ◐ B-1 (DAMES AND MOORE, 1981)
- ◑ EH-1 (ANACONDA MINERALS)
- DOMESTIC WELL



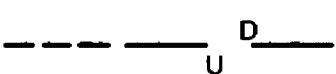




## TEST PITS

- ⊗ TP-1 (ANDERSON ENGINEERING/SEH, 2008)
- TP-2004A (SEH, 2004)
- ▣ TP-A (SEH, 2001)
- APB-1 (ANDERSON ENGINEERING, 1996)

## GEOLOGIC UNITS

e	EMBANKMENT FILL, RIPRAP	TK <sub>lp</sub>	LATITE PORPHYRY INTRUSIVES
f	ROAD FILL, PAVEMENT	P <sub>cu</sub>	CUTLER FORMATION - SILTSTONE, ARKOSE AND CONGLOMERATE
wr	WASTE ROCK	P <sub>hl</sub>	HERMOSA FORMATION (LOWER MEMBER) - SANDSTONE, SILTSTONE, SHALE, MINOR LIMESTONE OR DOLOMITE
ct	CALCINE TAILINGS	P <sub>i</sub>	QUARTZITE
so	SPENT ORE	M <sub>i</sub>	LEADVILLE LIMESTONE
f/mw/d	MISCELLANEOUS FILL, MINE WASTE (TAILINGS, WASTE ROCK, ORE), BURIED DEMOLITION DEBRIS	md	METADIORITE
Q <sub>al</sub>	ALLUVIUM	g	GREENSTONE
Q <sub>f</sub>	FAN DEPOSITS		
Q <sub>tw</sub>	TALUS, SLOPEWASH (COLLUVIUM)		
Q <sub>l</sub>	LANDSLIDE DEBRIS		

## SYMSOLS

	GEOLOGIC CONTACT		W.L. MEASURED 5/18/11
	BEDROCK FAULT; D * DOWN-THROWN SIDE, U * UP-THROWN SIDE		6/2/09 W.L. MEASURED ON DATE SHOWN
	STRIKE AND DIP OF BEDDING		W.L. DURING DRILLING/EXCAVATION
	TREND AND PLUNGE OF FOLIATION		

**AECOM**

AECOM Technical Services, Inc.  
717 17th ST., SUITE 2500  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN

GEOLOGIC LEGEND

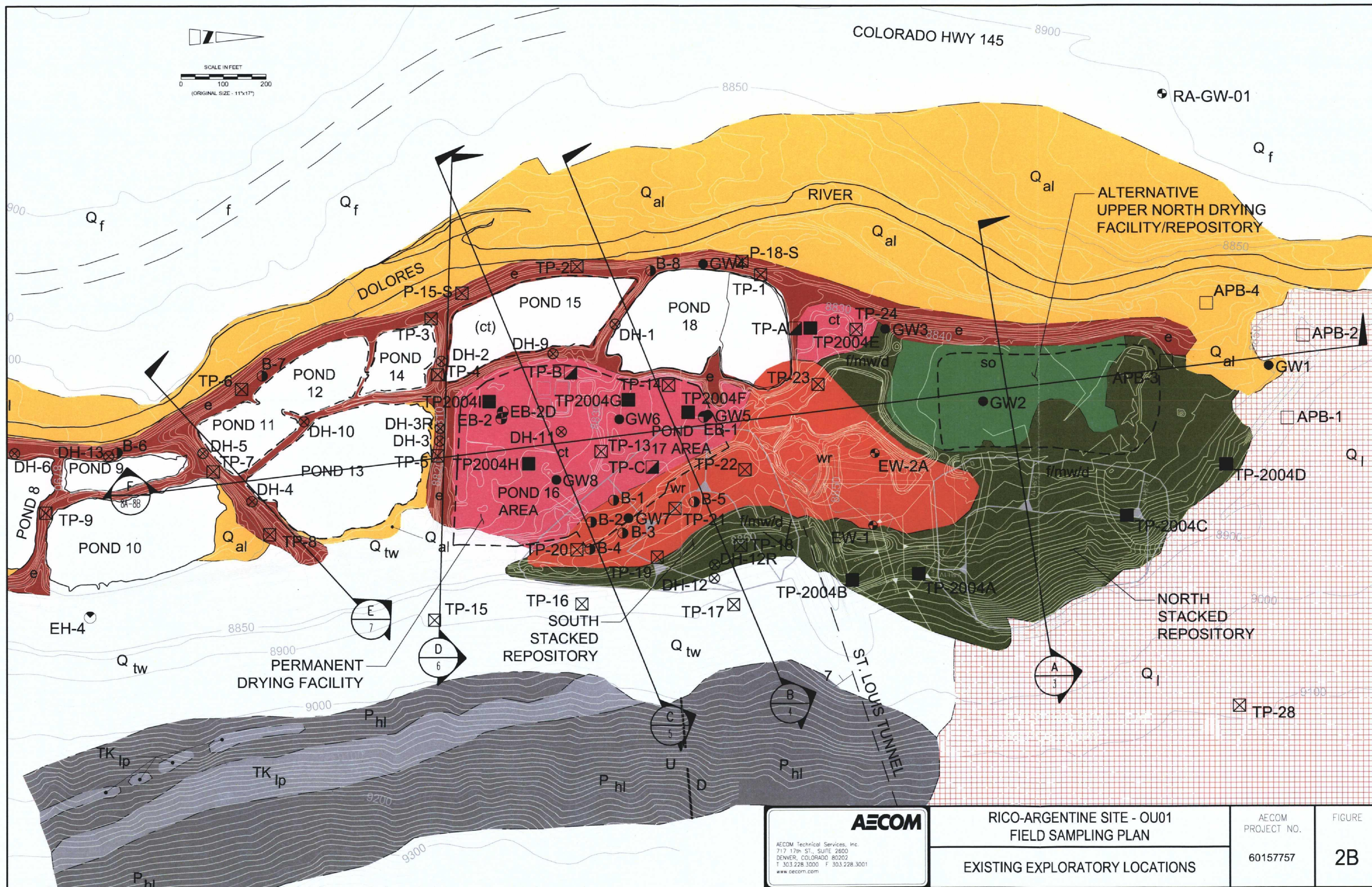
AECOM  
PROJECT NO.

60157757

FIGURE

2A





**AECOM**

AECOM Technical Services, Inc.  
717 17th St., Suite 2600  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

**RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN**

**EXISTING EXPLORATORY LOCATIONS**

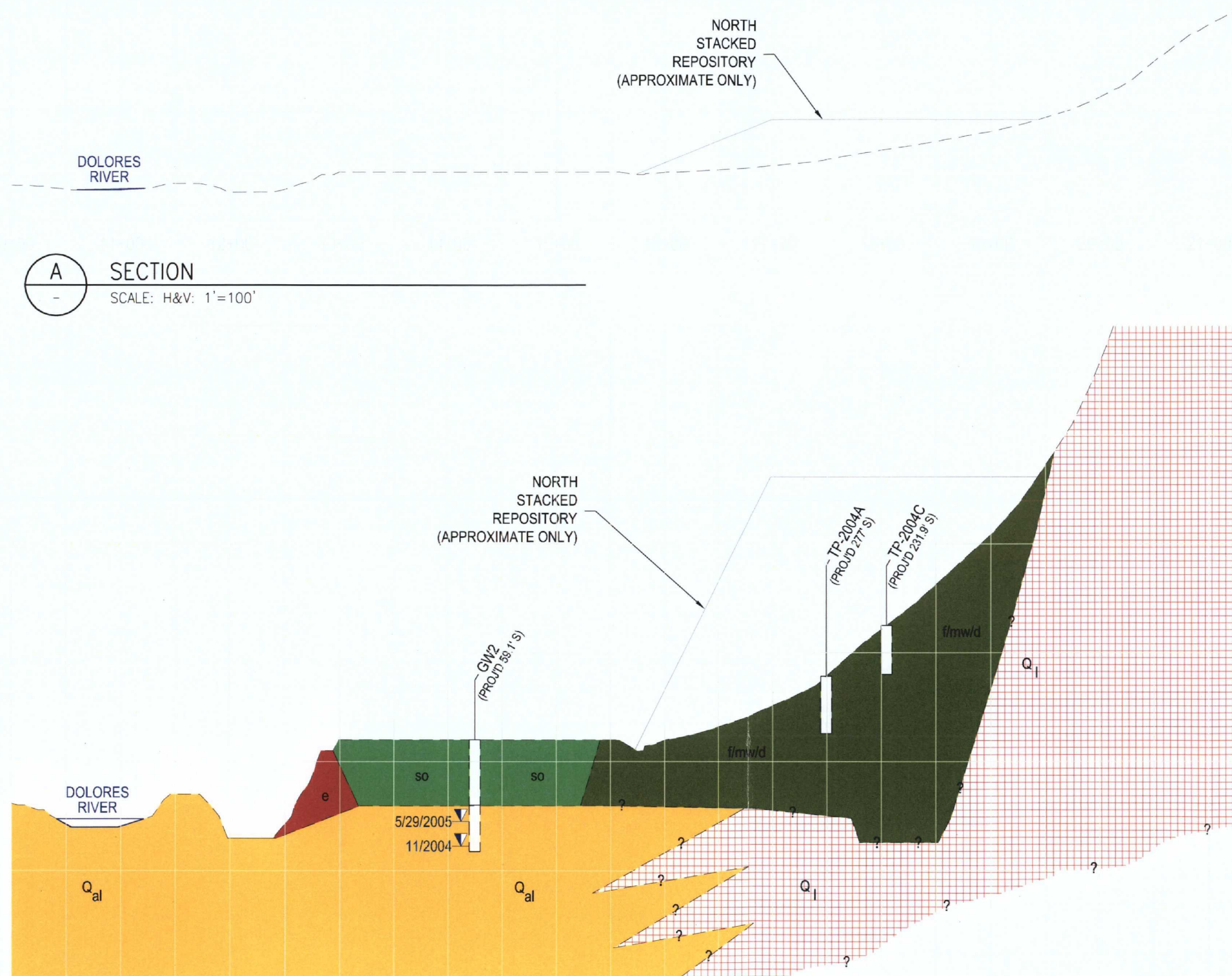
AECOM  
PROJECT NO.

60157757

FIGURE

**2B**





**A** SECTION (EXAGGERATED)  
SCALE: H: 1"=100', V: 1"=20'

**AECOM**  
AECOM Technical Services, Inc.  
717 17th ST., SUITE 2600  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

**RICO-ARGENTINE SITE - OU01**  
**FIELD SAMPLING PLAN**

**GEOLOGIC SECTION A-A**

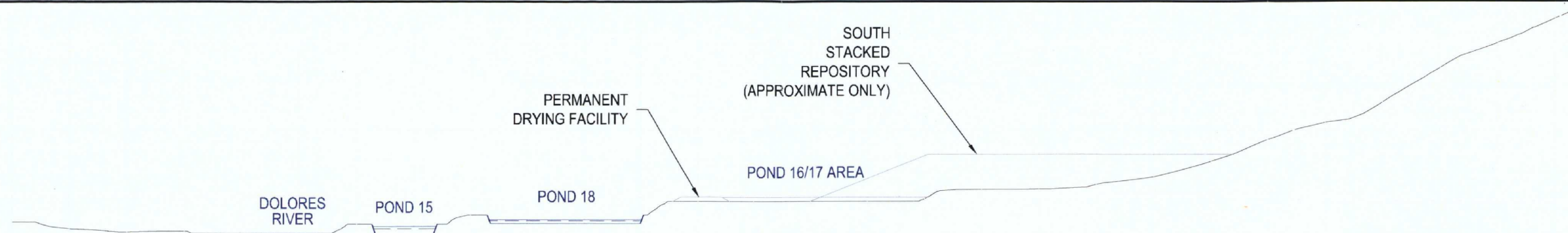
AECOM  
PROJECT NO.

60157757

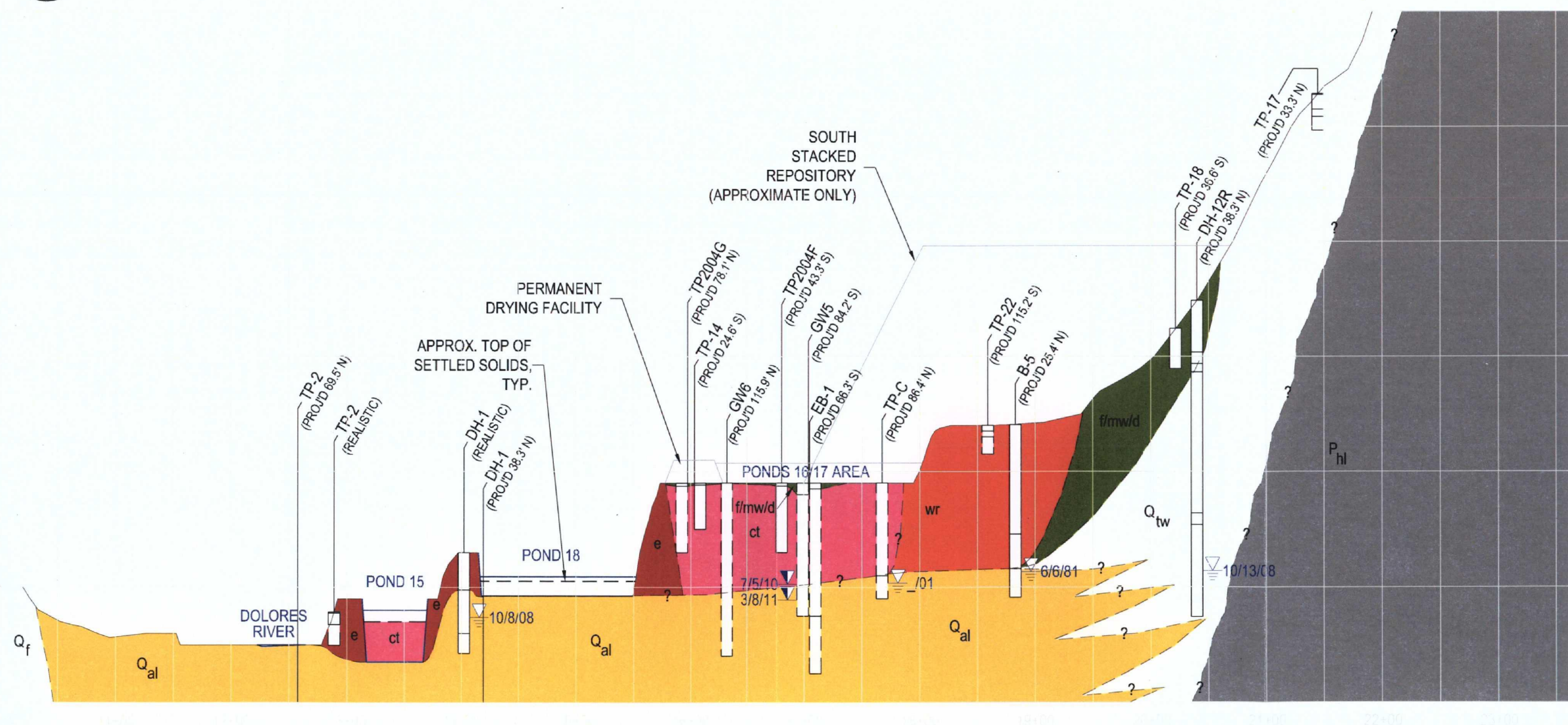
FIGURE

**3**





**B** SECTION  
SCALE: H&V: 1"=100'



**B** SECTION (EXAGGERATED)  
SCALE: H: 1"=100', V: 1"=20'

**AECOM**

AECOM Technical Services, Inc.  
717 17th St., Suite 2600  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN

GEOLOGIC SECTION B-B

AECOM  
PROJECT NO.

60157757

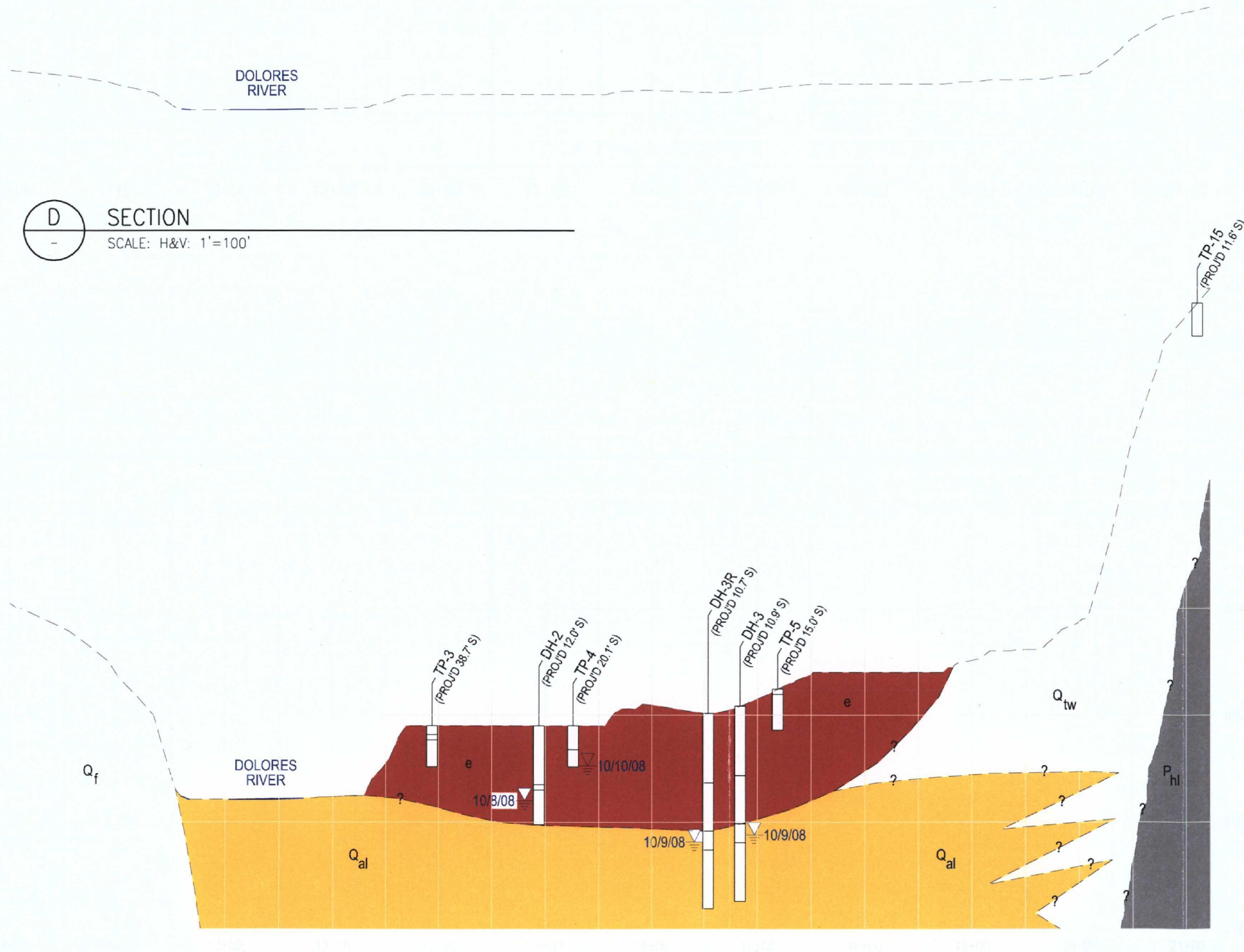
FIGURE

4









D  
-

SECTION (EXAGGERATED)

SCALE: H: 1'=100', V: 1"=20'

**AECOM**

AECOM Technical Services, Inc.  
717 17th ST., SUITE 2600  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN

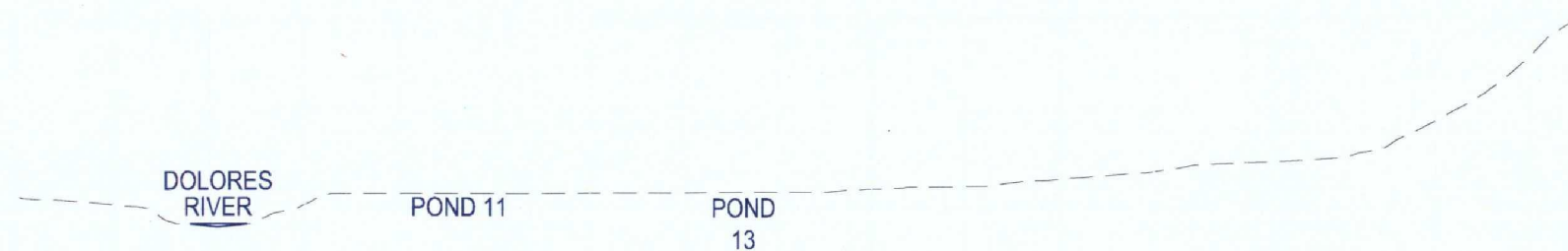
GEOLOGIC SECTION D-D

AECOM  
PROJECT NO.

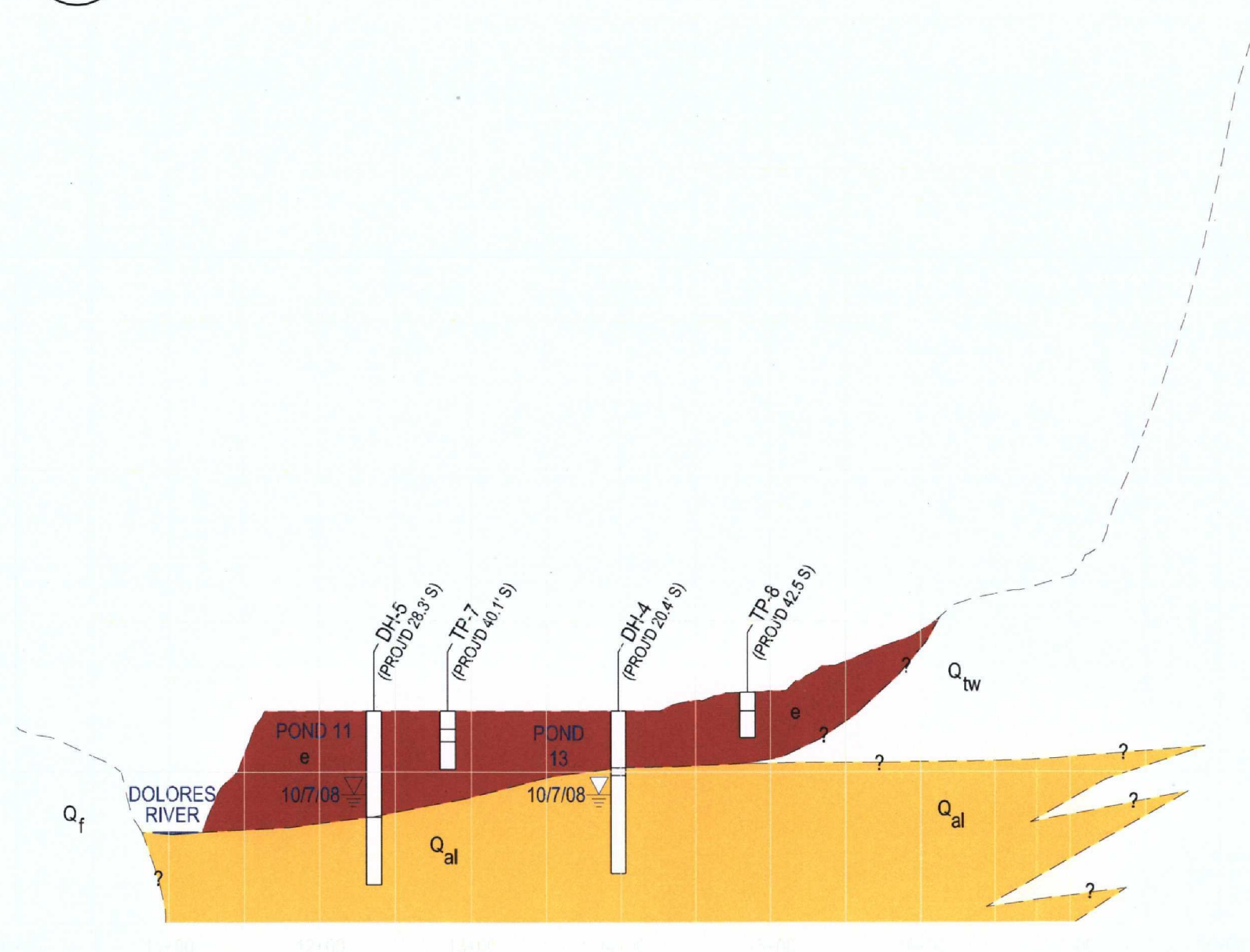
60157757

FIGURE

6



**E** SECTION  
SCALE: H&V: 1"=100'



**E** SECTION (EXAGGERATED)  
SCALE: H: 1"=100', V: 1"=20'

**AECOM**  
AECOM Technical Services, Inc.  
717 17th ST., SUITE 2600  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN

GEOLOGIC SECTION E-E

AECOM  
PROJECT NO.

60157757

FIGURE

7

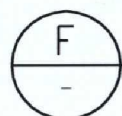






MATCH LINE - STA: 23+50  
SEE FIGURE 8A

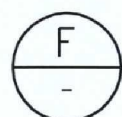
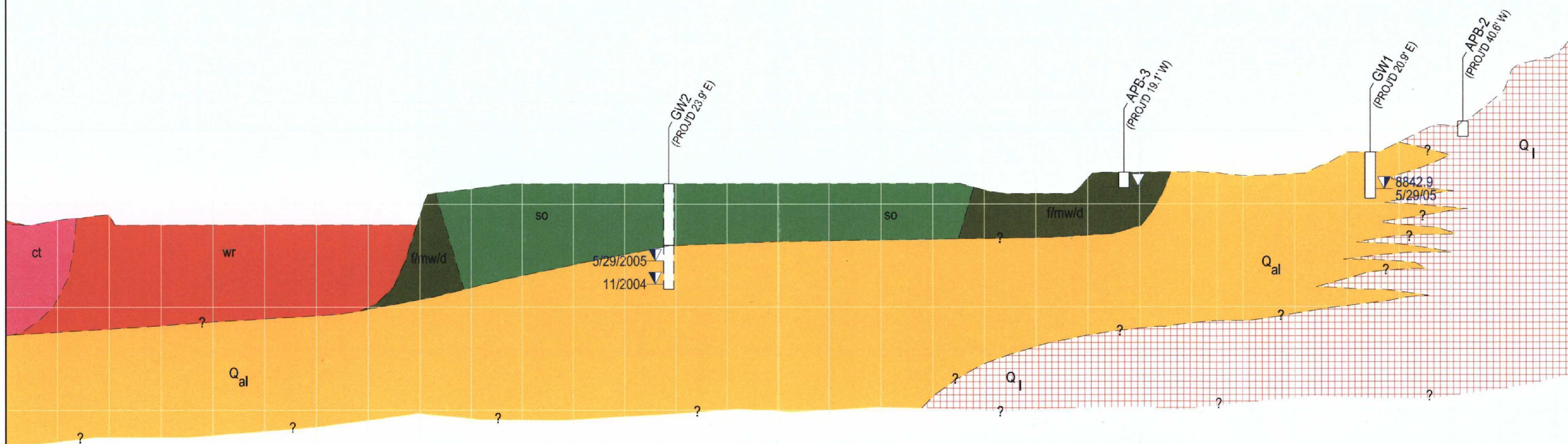
PERMANENT  
DRYING FACILITY



SECTION

SCALE: H&V: 1'=100'

MATCH LINE - STA: 23+50  
SEE FIGURE 8A



SECTION (EXAGGERATED)

SCALE: H: 1'=100', V: 1"=20'

**AECOM**

AECOM Technical Services, Inc.  
717 17th ST., SUITE 2600  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN

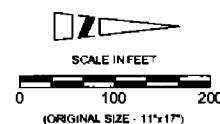
GEOLOGIC SECTION F-F (sheet 2 of 2)

AECOM  
PROJECT NO.

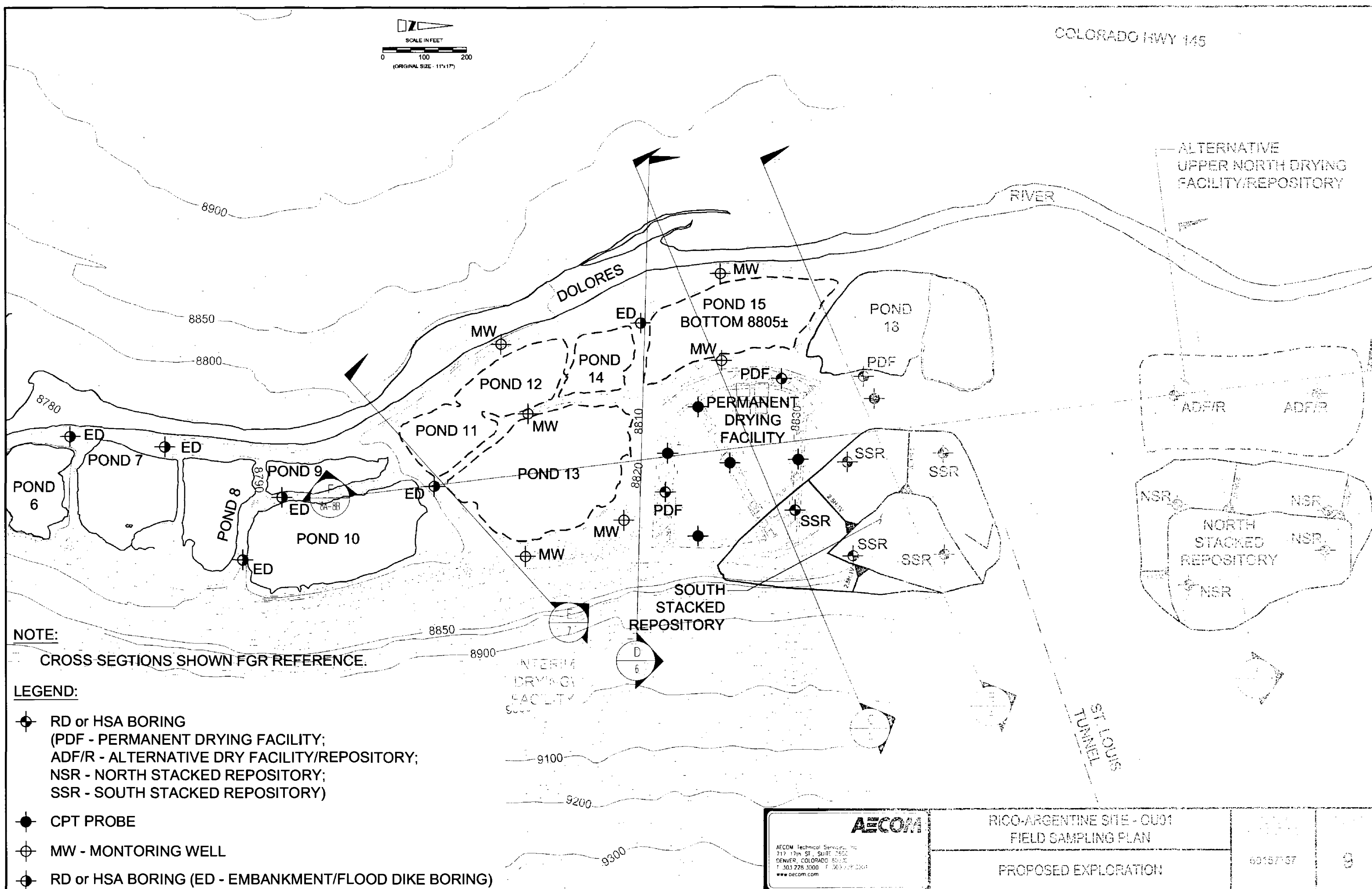
60157757

FIGURE

8B



COLORADO HWY 145



**NOTE:**

CROSS SECTIONS SHOWN FOR REFERENCE.

**LEGEND:**

- RD or HSA BORING (PDF - PERMANENT DRYING FACILITY; ADF/R - ALTERNATIVE DRY FACILITY/REPOSITORY; NSR - NORTH STACKED REPOSITORY; SSR - SOUTH STACKED REPOSITORY)
- CPT PROBE
- MW - MONITORING WELL
- RD or HSA BORING (ED - EMBANKMENT/FLOOD DIKE BORING)

**AECOM**

AECOM Technical Services, Inc.  
717 17th St., Suite 2500  
DENVER, COLORADO 80202  
T 303.228.3000 F 303.228.3001  
www.aecom.com

RICO-ARGENTINE SITE - OU01  
FIELD SAMPLING PLAN

PROPOSED EXPLORATION

60187-57

9